ORIGINAL ARTICLE

Joint effect of high blood pressure and physical inactive on diabetes mellitus: a population-based cross-sectional survey

NIKSON SITORUS[1], APRIZAL SATRIA HANAFI[2], DEMSA SIMBOLON[3], MARTINA[2]
[1] Center for Research and Development of Public Health Efforts, National Institute of Health Research and Development, Ministry of Health RI, Jakarta, Indonesia; [2] Alumnus of Master of Epidemiology Student, School of Public Health, University of Indonesia, Depok, Indonesia; [3] Department of Public Health, Health Polytechnic of Bengkulu Ministry of Health, Bengkulu, Indonesia

Keywords

Joint effect • Blood pressure • Physical inactivity • Diabetes mellitus • Indonesia

Summary

Introduction. *The relationship of high blood pressure and physical inactivity to diabetes mellitus is well known, but not many studies have known the joint effect of the two in causing diabetes mellitus. This study aims to evaluate the joint effect of high blood pressure and less physical activity against Diabetes Mellitus (DM) in Indonesia.*
Methods. *This is a cross-sectional study. Subjects in this study were the age group ≥ 21 years old who were followed by the interview. We investigated factors related to DM in Indonesia associated with blood pressure and physical activity by controlling other confounding variables. Statistical analyses were conducted using logistic regression. Age, sex, education level, marital status, occupation, body mass index, residence area, stress, fruit, and vegetable consumption were adjusted for in the multivariate model.*
Results. *The prevalence of DM was 3.86% among respondents. Multivariate analysis showed that people who had hypertension and less physical activity had a risk of 3.68 (95% CI, 2.43-5.34) times having DM. People who had hypertension and enough physical activity had a risk of 2.33 (95% CI, 1.65-6.43) times having DM. While people who do not have hypertension and had less physical activity had a risk of 1.81 (95% CI, 1.34-3.62) times.*
Conclusions. *People with hypertension and less physical activity have the greatest risk of developing DM.*

Introduction

In 2014, according to WHO there were 422 million adults aged over 18 who lived with Diabetes Mellitus (DM) [1]. Prevalence of DM in Indonesia has continued to increase, from 5.7% in 2007, to 6.9% in 2013, and increased again to 8.5% in 2018 [2-4]. Indonesia is the 4th country with the highest prevalence of DM in the world. Even the number of people with DM continues to increase from year to year. WHO data estimates that the number of people with DM in Indonesia will increase significantly to 21.3 million in the next 2030 [5].
Lifestyle factors and clinical factors are among the other factors that have a major influence on the incidence of DM. According to the study from Coldberg (2016) and Williams (2013) high blood pressure and less physical activity were the main predictor factors that trigger an increase in blood sugar levels. So, the two factors must be controlled as prevention efforts [6].
Based on these data it can be seen that the prevalence of DM patients increases every year in Indonesia and the joint effects of blood pressure and physical activity in influencing DM events have never been done. In previous study by Hanafi and Prihartono (2018), a similar study was carried out with different study outcomes [7]. This study aims to find the joint effects of blood pressure and physical activity with DM by controlling other variables such as age, sex, marital status, education level, occupation, residence area, body mass index, stress, vegetable consumption, and fruit consumption.

Methods

Ethical considerations

The IFLS-5 survey procedures had been approved by Institutional Review Boards (IRBs) in the United States at Rand Corporation, Santa Monica, California and in Indonesia at Ethics Committees of Gadjah Mada University.

Study design

This study uses a cross-sectional design using data from the Indonesian Family Life Survey-5 [8]. The survey collected information on individual, household and community level data using multistage stratified random sampling. IFLS is a longitudinal household survey involving both questionnaire and anthropometric measurements, and which was collected under the supervision of the Rand Corporation. IFLS-5 was conducted in 13 provinces in Indonesia [9].
IFLS-5 was conducted in September 2014-March 2015 on 50,148 individuals. The study population was the population who became the subject of IFLS-5 research

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in 2014. While the sample was the age group ≥ 21 years who followed the interview and had questionnaire data on important variables [10].

Study variable

We include demographic information, individual characteristics and behavioral factors as confounding. We categorize the level of education completed by respondents to low (under Senior High School), middle (Senior High School) and high (College or University), while marital status was classified as single, married, separated, live divorced, death divorced. Occupations were categorized as working and not working.

Physical activity was assessed through a series of questions a brief form modified from the International Physical Activity Questionnaire (IPAQ) on the type and time of physical activity involved in, in all parts of life: work, home and exercise and then classified as enough and less physical activity [11].

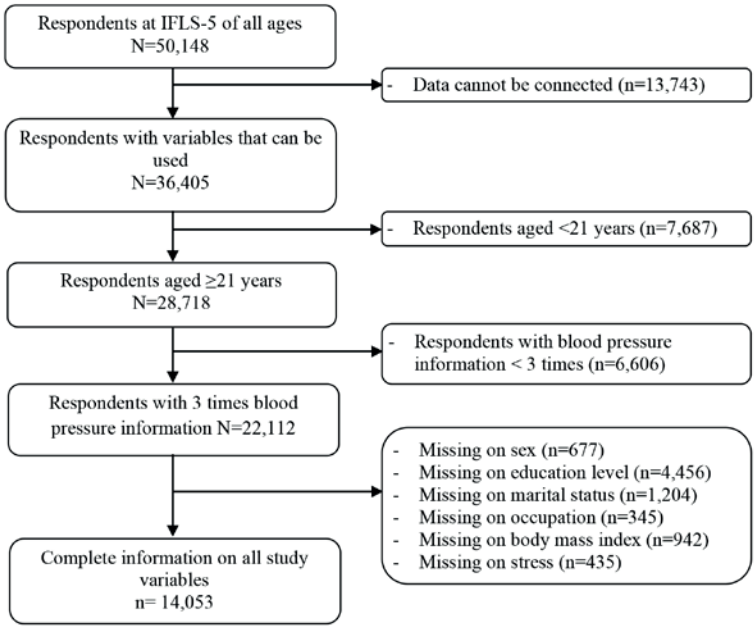
DM is assessed through questions ever diagnosed or not done by doctors or paramedics. We also measured respondents' fiber consumption in the past week, which was seen from the consumption of fruits and vegetables. Body mass index (BMI) < 27 kg/m^2: normal weight; and ≥ 27.0 kg/m^2: obesity derived from the height and weight measured during the physical examination, these criteria were determined based on the Ministry of Health of the Republic of Indonesia in 2013. Height measured by the Seca plastic height board model 213 and weight was measured using Camry model EB1003 scale. In this study the measurement of body weight and height was carried out by the interviewer or enumerator who was competent in their field and had received previous training.

Blood pressure was measured 3 times at an individual, using Omron meter HEM 7203. The first measurement was done at the beginning of the interview with the next two steps taken during the interview. The average of the 3 measurements was used for the current analysis. According to the JNC 7 blood pressure was categorized into 4 levels, namely normal (< 120/80 mmHg), prehypertension (120-139/80-89 mmHg), hypertension stage 1 (140-159/90-99 mmHg), and hypertension stage 2 (≥160/100 mmHg). We classify respondents as hypertension if their blood pressure ≥ 140/90 mmHg based on the criteria of JNC 7. Blood pressure measurement was carried out by the interviewer or enumerator who was competent in their field. Only respondents with complete information and blood pressure measurements were taken 3 times included in the analysis. After processing the data all of our study variables continued by making the joint variable of blood pressure and physical activity into one variable. The joint variables are divided into 4 categories, namely groups of people who are not hypertensive and have enough physical activity, groups of people who are not hypertensive and have less physical activity, groups of people who are hypertensive and have enough physical activity, and groups of people who are hypertensive and have less physical activity.

Statistical analysis

Logistic regression was performed to calculate the risk in all age groups. This study includes age, sex, education level, marital status, occupation, body mass index, residence area, stress, fruit and vegetable consumption and as potential confounders variables by including them in multivariable analysis between blood pressure and physical activity to DM. If there is a difference of more than 10% between POR crude and POR adjusted then these variables were considered as confounding variables and not included in the next model. The same procedure was used to estimate adjusted odds ratio (and 95% CI) for DM [12]. Finally, the joint effect (and 95% CI) of hyper-

Fig 1. Selection of study sample flowchart.



tension and physical activity, individual effect of hypertension among people with enough physical activity, and effect of people with less physical activity among non hypertension on DM were evaluated (Fig. 1).

Results

The description of each study variable can be seen in Table I. Of the 14,053 respondents, the proportion of DM in Indonesia was 3.86%. While the proportion of hypertension and less physical activity was 18.50% and 21.20%, respectively.

Table I shows that the majority of respondents were 21-44 years old (62.61%), women (54.52%), married (78.70%), low education (85.76%), working (81.80%), living in rural areas (54.79%), not hypertensive (81.50%), not obese (73.81%), enough physical activity (78.80%), not stressed (62.72%), consuming vegetables 7 days/week (48.39%), and consuming fruits 7 days / weeks (39.86%). The results of joint variables of blood pressure and physical activity showed that most respondents were in the category of non-hypertensive and enough physical activity (64.93%) and the least in the hypertension and less physical activity group (4.63%).

Based on Table II shows that the proportion of DM is highest in the 45-59 year age group (51.48%), women (55.54%), married people (83.76%), low education (74.17 %), people who live in urban areas (67.16%), obese people (54.61%), people who have enough physical activity (62.18%). Variables of age, sex, education level, marital status, residence area, blood pressure, body mass index, physical activity, fruit and vegetable consumption were significantly associated with DM with p value < 0.05. While the occupation and stress variables do not show a significant relationship with a p value > 0.05.

Based on the joint variable blood pressure and physical activity the proportion of the highest diabetes mellitus is indeed in the group of people who are not hypertension and have enough physical activity (33.95%). However, this is due to the fact that the proportion in this group is the highest, namely 64.93% (Tab. II). Interestingly, the group with the second and third highest proportion of DM was a group of people with hypertension and enough physical activity (28.23%) and groups of people with hypertension and less physical activity (19.93%). While the group of people without hypertension and less activity the least proportion of DM. So, it can be concluded that hypertension is a significant factor in influencing the proportion of DM than physical activity (Tab. III).

Table IV shows that the highest risk of DM is in the group of people who have hypertension and less physical activity which is 3.68 times, while those in hypertension and less physical activity risky 2.33 times, in groups of people who are not hypertension and have less physical activity risky 1.81 times greater with a group of people who are not hypertension and have enough physical activity as a reference.

Tab. I. Respondents features.

Characteristic	Total	Percentage
Diabetes mellitus		
Yes	542	3.86
No	13,511	96.14
Age (years)		
21-44 (adults)	8,799	62.61
45-59 (middle)	3,543	25.21
60-74 (elderly)	1,498	10.66
75-90 (old)	213	1.52
Sex		
Male	6,392	45.48
Female	7,661	54.52
Marital status		
Single	1,598	11.37
Married	11,060	78.70
Separated	80	0.57
Live divorced	297	2.11
Death divorced	1,018	7.24
Education		
High	1,503	10.70
Middle	498	3.54
Low	12,052	85.76
Occupation		
Yes	11,496	81.80
No	2,557	18.20
Residence area		
Rural	7,700	54.79
Urban	6,353	45.21
Blood pressure		
Non-hypertension	11,453	81.50
Hypertension	2,600	18.50
Body mass index		
Normal	10,372	73,81
Obesity	3,681	26,19
Physical activity		
Enough	11,074	78,80
Less	2,979	21,20
Stress		
No	8,814	62.72
Yes	5,239	37.28
Vegetable consumption		
7/week	6,800	48.39
4-6/week	3,725	26.51
1-3/week	3,058	21.76
Never	470	3.34
Fruit consumption		
7/week	5,601	39.86
4-6/week	3,919	27.89
1-3/week	3,464	24.65
Never	1,069	7.61
Joint variable of blood pressure and physical activity		
Non-hypertension + enough	9,125	64.93
Non-hypertension + less	2,328	16.57
Hypertension + enough	1,949	13.87
Hypertension + less	651	4.63

Tab. II. Frequency of diabetes mellitus according to individual characteristics.

Characteristics	Diabetes mellitus		Non-diabetes mellitus		P value	POR	95% CI
	N = 542	%	N = 13,512	%			
Age (years)							
21-44 (adults)	180	33.21	8,619	63.79		1	1
45-59 (middle)	279	51.48	3,264	24.16	< 0.001	1.68	1.21-2.15
60-74 (elderly)	80	14.76	1,418	10.50	< 0.001	2.70	2.06-3.53
75-90 (old)	3	0.55	210	1.55	< 0.001	4.09	3.37-4.95
Sex							
Male	241	44.46	6,151	45.53		1	1
Female	301	55.54	7,360	54.47	< 0.001	1.04	0.87-1.24
Marital status							
Single	17	3.14	1,581	11.70		1	1
Married	454	83.76	10,606	78.50	< 0.001	3.98	2.44-6.47
Separated	1	0.18	79	0.58	0.011	1.17	1.05-8.95
Live divorced	14	2.58	283	2.09	0.045	4.60	2.24-9.43
Death divorced	56	10.33	962	7.12	0.005	5.41	3.12-9.37
Education							
High	98	18.08	1,405	10.40		1	1
Middle	42	7.75	456	3.38	0.035	2.02	1.60-2.53
Low	402	74.17	11,650	86.23	0.004	2.66	1.91-3.71
Occupation							
Yes	11,135	82.41	361	66.61		1	1
No	2,376	17.59	181	33.39	0.051	2.34	1.95-2.82
Residence area							
Rural	178	32.84	7,522	55.67		1	1
Urban	364	67.16	5,989	44.33	< 0.001	2.56	2.14-3.08
Blood pressure							
Non-hypertensive	281	51.85	11,172	82.69		1	1
Hypertensive	261	48.15	2,339	17.31	< 0.001	2.22	1.18-3.26
Body mass index							
Normal	246	45.39	10,126	74,95		1	1
Obesity	296	54.61	3,385	25.05	< 0.001	2.31	1.46-3.67
Physical activity							
Enough	337	62.18	10,373	79,47		1	1
Less	205	37.82	2,774	20,53	< 0.001	1,76	1,01-3,06
Stress							
No	322	59.41	8,492	62.85		1	1
Yes	220	40.49	5,019	37.15	0.066	1.15	1.07-1.37
Vegetable consumption							
7/week	257	47.42	6,543	48.43		1	1
4-6/week	154	28.41	3,571	26.43	< 0.001	1.19	0.69-2.04
1-3/week	116	21.40	2,942	21.77	< 0.001	1.30	1.16-2.28
Never	15	2.77	455	3.37	< 0.001	2.11	1.17-2.86
Fruit consumption							
7/week	246	45.39	5,355	39.63		1	1
4-6/week	158	29.15	3,761	27.84	< 0.001	1.31	0.90-1.93
1-3/week	105	19.37	3,359	24.86	< 0.001	1.44	1,09-2,12
Never	33	6.09	1,036	7.67	< 0.001	2.44	1.89-3.08

Tab. III. Frequency of diabetes mellitus according to joint variable of blood pressure and physical activity.

Characteristics	Diabetes mellitus		Non-diabetes mellitus		POR	95% CI
	N = 542	%	N = 13,512	%		
Non-hypertension + enough	184	33.95	8,941	66.18	1	1
Non-hypertension + less	97	17.90	2,231	16.51	1.85	1.17-3.53
Hypertension + enough	153	28.23	1,796	13.29	2.52	1.86-5.27
Hypertension + less	108	19.93	543	4.02	3.82	2.54-9.35

Tab. IV. Final model of joint variable of blood pressure and physical activity against diabetes mellitus.

Joint variable of blood pressure and physical activity	Diabetes mellitus		Non-diabetes mellitus		POR (95% CI)
	N = 542	%	N = 13,512	%	
Non-hypertension + enough	184	33.95	8,941	66.18	1.00 (reference)
Non-hypertension + less	97	17.90	2,231	16.51	1.81 (1.34-3.62)
Hypertension + enough	153	28.23	1,796	13.29	2.33 (1.65-6.43)
Hypertension + less	108	19.93	543	4.02	3.68 (2.43-5.34)

Adjusted by age, sex, education, occupation, residence area, body mass index, and fruit and vegetable consumption.

Discussion

The starting point for healthy living with diabetes is an early diagnosis, the longer a person lives with undiagnosed and untreated diabetes, the worse the health outcome. For those diagnosed with diabetes, a series of interventions can reduce the risk of bad prognosis diabetes, regardless of what type of diabetes they may have. These interventions include blood pressure control, blood glucose, through a combination of diet, physical activity and, if necessary, treatment, to facilitate early control [1].

Our study shows that (48.15%) people with DM have hypertension. Most people with DM were female. This is in line with several other studies that show that women suffer more from DM [13-17]. Most respondents have low education and working [18, 19]. This study also shows that most people with DM are adults (21-44 years) and married. This is in line with several other studies. The results of the same study were also mentioned by other studies [18].

This study shows that in non-diabetes mellitus patients have enough physical activity than less physical activity. Other studies suggest that physical activity can improve blood sugar control [20].

This cross-tabulation analysis also shows that the variables of age, sex, education level, marital status, residence area, blood pressure, body mass index, physical activity, fruit and vegetable consumption are significantly associated with DM. While the occupation and stress variables do not show a significant relationship.

Physical activity includes all movements that increase energy use. Exercise improves blood glucose control in DM, reduces cardiovascular risk factors, contributes to weight loss, and improves well-being [21, 22]. Enough physical activity can prevent or delay the development of diabetes [23]. Regular exercise also has considerable health benefits in people with diabetes (e.g., increased cardiovascular fitness, muscle strength, insulin sensitivity etc. [24]. Challenges related to blood glucose management. Insulin in the muscles and liver can be modified immediately by physical activity and regular physical activity [25]. Aerobic exercise increases muscle glucose up to 5-fold. After exercise, glucose uptake remains increased by insulin-independent (2 hours) and insulin dependent (up to 48 hours) [26].

Physical activity is not the only trigger factor for DM in the equation below explained about the joint effects of blood pressure and physical activity on the occurrence of DM. The pathophysiological mechanism that explains the relationship between hypertension and the incidence of DM is not yet clear. However high blood pressure has been shown to induce microvascular dysfunction, which can contribute to the pathophysiology of the development of diabetes [27, 28]. Endothelial dysfunction associated with insulin resistance is also associated with hypertension, and biomarkers of endothelial dysfunction are predictors of DM [29].

Elevated blood pressure values are a common finding in patients with DM and are thought to reflect, at least in part, the impact of the underlying insulin resistance on the vasculature and kidney [30]. On the contrary, accumulating evidence suggests that disturbances in carbohydrate metabolism are more common in hypertensive individuals [31, 32]. Thereby indicating that the pathogenic relationship between DM and hypertension is actually bidirectional.

In the multivariate analysis of joint variables of blood pressure and physical activity was found that hypertension had a greater effect of 2.33 times in causing DM than less physical activity ie 1.81. However, the risk of DM increases significantly, which is 3.68 times when hypertension and less physical activity appear together. In the above results, the percentage of the increased risk of DM events can be calculated when hypertension and less physical activity appear together as follows:

- (3.68-1) = (2.33-1) + (1.81-1);
- 2.68 = 1.33 + 0.81;
- 2.68 = 2.14;
- 2.68 > 2.14;
- 2.68-2.14 / 2.68 = 20.14%.

This means that the risk for developing DM will increase by 20.14% when hypertension and less physical activity appear simultaneously due to the interaction of both.

This study has limitations, because this is a Cross-Sectional study, so it cannot determine causal relationships. Longitudinal studies are needed to assess the joint effect of blood pressure and physical activity on DM to draw strong conclusions about the causal pathways of this relationship.

Conclusions

The proportion of DM in Indonesia who became respondents in IFLS-5 is 3.86%. The combination of hypertension and less physical activity have a risk of 3.86 times to suffer from DM compared to those who not hypertension and have enough physical activity. Hypertension and less physical activity together show a greater

association with DM than hypertension or less physical activity alone. The continued increase in DM prevalence makes it necessary to increase health promotion efforts including the addition of nutrition counseling and counseling as well as joint sports activities (gymnastics) in integrated coaching activities. Communities, especially those classified as high-risk (hypertension and less physical activity) can realize the importance of independently performing DM screening in this case was blood pressure, blood glucose level, general obesity of body weight and height.

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Conflict of interest statement

The authors declare no conflict of interest.

Authors' contributions

NS: conceived of the presented idea, collect the data, performed the analysis. ASH: conceived of the presented idea, conceived and designed the analysis, contributed data or analysis tools, performed the analysis, contributed to the interpretation of the results. DS: verified the analytical methods, designed the model and the computational framework, other contribution. M: developed the theory and performed the computations, performed the analysis, derived the models and analyzed the data, wrote the paper. All authors discussed the results and contributed to the final manuscript.

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Correspondence: Aprizal Satria Hanafi, School of Public Health, University of Indonesia Depok 16424, Indonesia - E-mail: aprizalsatriahanafi@gmail.com

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